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ECHINOCOCCOSIS: EPIDEMICS AND ECONOMICS

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Introduction

Echinococcosis is amongst the world's most serious parasitic zoonoses. Human cystic echinococcosis (CE) is caused by the larval stage of *Echinococcus granulosus* and results in a space occupying lesion mainly in the liver or lungs and occasionally in other organs such as the central nervous system [1]. It can cause serious human morbidity or even death if untreated. Dogs are the normal definitive hosts and humans are infected by close contact with dogs or through contamination of food or water with dog faeces containing eggs of *Echinococcus*. Human alveolar echinococcosis (AE) is caused by *E. multilocularis* [1]. The larval stage of this parasite causes a serious space occupying lesion, initially in the liver but infiltrates and metastasises to other organs. It is usually fatal if untreated [2]. AE can result from close contact with definitive hosts which include both foxes and dogs or through contaminated food or water.

Epidemiology

CE has a global distribution. Hence it is found in most countries in the world [3]. The transmission cycle is usually maintained through domestic farm animals, most commonly sheep but can include cattle, goats, camels and others, and dogs. Dogs are infected through consumption of offal, whilst domestic animals are infected by grazing on contaminated pasture. The parasite is seen at the highest prevalences where there is unregulated or poorly supervised slaughtering of domestic animals which allows dogs to scavenge on offal and hence become infected and further transmit the parasite to humans. The highest human incidences are seen in western China, central Asia, eastern Europe, Mediterranean countries, parts of Sub-Saharan Africa and some Latin American countries. In recent years in central Asia the incidence of CE has increased [4] and this may be the result of changes in farming practices which included privatization and abandonment of many large meat processing units that occurred following the dissolution of the Soviet Union. The increase in dog population is also a significant contributing factor [5]. In Kazakhstan we have found high prevalences of CE in sheep across southern districts of the country. These correspond to areas where the most human CE cases are reported [6]. We have also found that farms dogs have the highest prevalence of infection of any dog population, reaching 20% or more[7].

Increases in CE have been observed in eastern Europe for similar reasons [8,9]. Elsewhere the disease is also strongly associated with poverty and unregulated home slaughtering of animals.

AE is entirely confined to the northern hemisphere and is found across northern Eurasia from France in the west and Iran in the south to Siberia in the north and Japan in the east [10]. AE is also found in Canada and northern parts of the USA. Across most of its range, the disease is sporadic and is believed to be transmitted directly or indirectly from foxes to humans. In Europe we have been seeing substantial increases in human AE across France, Switzerland, Austria, Germany, Poland and the Baltic states [11–15]. This has been linked to dramatic increases in fox populations. Foxes have also colonized city environments which has increased the possibilities of transmission to humans. Further east in central Asia there is also evidence of substantive increases in the numbers of human AE cases. This is illustrated by the Kyrgyz Republic [16,17] where there are now reports in excess of 200 cases per annum. The epidemiology of human CE in central Asia may be different, as there is evidence that the parasite has colonized dogs and high prevalences of *E. multilocularis* have been found in dog populations in both Kazakhstan [18] and Kyrgyzstan [19]. Dogs have much closer contact with humans and thus increase the likelihood of transmission. The colonization of dogs may be linked to the

increase in dog population and rural poverty. Feeding the dog is not high priority so she will go hunting for small rodents and hence become infected. In the Kyrgyz republic in Naryn Oblast we have found that hunting dogs and dogs allowed to roam have substantially higher prevalences than dogs that are tied most of the time [19].

Further east in China there are huge numbers of cases of AE. China perhaps has over 90% of all cases of human AE, with our estimates suggesting 16,000 or more cases per annum [10]. These cases are largely confined to western China and the Tibetan plateau. In some communities prevalences of 5% or more are found [20]. Often the communities with the highest prevalences are characterized by extreme poverty and geographical isolation. There are often many stray dogs in these communities. However, the local population does not have the resources to feed these dogs, whilst on the other hand killing them is prohibited for religious reasons. Thus large populations of semi stray dogs will feed on rodents and become infected. These dogs are allowed to freely wander in and out of the homes of the local population, thus promoting transmission. Naturally the parasite transmits between rodents and Tibetan foxes and these stray dogs have now created a domestic cycle which increases the risk to humans. In addition degradation of the landscape, caused by overgrazing, has facilitated an increase in population of susceptible rodent species which in turn has facilitated transmission of the parasite [21].

In the north the parasite is found throughout Russia and large numbers of case reports and case series are in the literature from across Russia documenting hundred if not thousands of cases reported since the middle of the last century (for examples see [22-24]). The epidemiology of transmission to humans is less clear.

The parasite is now endemic in Hokkaido island in Japan, having been introduced with red foxes in the early part of the last century. Approximately 10-20 human cases are reported annually [25].

In north America, the only substantial numbers of human cases were reported from St Lawrence Island in Alaska [26] Elsewhere in north America, there has been widespread reports of foxes infected with *E. multilocularis*, but human cases are very rare [27]. This might change as recently European genotypes, possible imported with dogs into Canada have been recorded [28] . It is hypothesized that European (or Asian) genotypes are much more likely to cause disease in humans than the genotype predominantly found in north American foxes.

Economics

Both forms of human echinococcosis are serious human diseases and expensive to treat. Surgical treatment of CE may cost US$1000 or more in a low income country, and several times that amount in a high income country [29]. With thousands of cases being treated annually in central Asia this results in a substantive economic burden. In addition, individuals may require prolonged nursing care whilst undergoing treatment resulting in substantial losses of income. Even where treatment is available, which, is often not the case in low income countries or remote areas, there is still a 2% case fatality rate during treatment. There is also evidence that even successfully treatment individuals are less able to work following recovery.

Alveolar echinococcosis is much more difficult to treat. In Europe it may cost more than $100,000 to treat an individual case of AE [2]. Following surgical resection of the lesion, patients then require a prolonged course of anthelmintic therapy for years or even life long to prevent recurrence. In severe cases liver transplantation may be the only option. In the absence of such aggressive treatment, the case fatality rate approaches 100%.

CE also has substantive economics costs to livestock. These include the loss of edible offal, the decrease in productivity in terms of reduced meat, milk and wool production, [30-32] and decreased quality of meat[33] from infected animals. This is often overlooked but can be much higher than the direct costs to human health.

Control

CE can be successfully controlled or eliminated. This is achieved by regular treatment of dogs with anthelmintics, control of slaughtered animals and education. Thus elimination of the disease was first achieved in Iceland and later in New Zealand, Tasmania and Cyprus. These successful programmes were on islands where reintroduction can be easily prevented. Continental systems are more of a

challenge. However, substantial progress has been made in some Latin American countries and European countries. Recently there has also been the development of a vaccine which can prevent infection in sheep [34] and may prove a useful tool the control the disease. Despite the effort and complexity required to successfully control and eliminate this parasite, it is highly cost effective and should also be seen as an investment which will result in a positive return as well as a benefit to public health.

Control of AE remains a challenge due to the parasite naturally occurring in wild life cycling between foxes and small mammals. Where the parasite has spilled over into the dog population, regular treatment of dogs will ameliorate the risk to humans. Otherwise the mass treatment of foxes by distributing praziquantel impregnated baits has shown success, but is logistically difficult and expensive.

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